ONR SEMI-ANNUAL PRODUCTIVITY REPORT, 01 OCT 1994 31 MAR 1995

PRINCIPAL INVESTIGATOR: Lokendra Shastri

INSTITUTION: International Computer Science Institute

PROJECT TITLE: Spatio-temporal Neural Networks for Vision, Reasoning
                        and Rapid Decision Making (N00014-93-1-1149)

Number of ONR supported:

    Papers published in refereed journals: 0
    Papers accepted for publication in referred journals: 1
    Papers under review for publication in referred journals: 0
    Books or book chapters published: 1
    Books or book chapters in press: 1

Number of ONR supported patents/inventions filed 0 or granted 0.

Number of presentations:
    Invited: 2
    Contributed: 1

Trainee Data:
No. of grad. students: 1, Male Non-US Citizen

Number, cost and description of equipment items costing more than $1,000 that were purchased on your ONR grant.

None

Awards/Honors to PI and/or to members of PI's research group (please describe):

None

Brief description of all trasitions (or intended transitions) of your ideas or techniques to industry, to military laboratories or to military application.

As mentioned in the attached report, we have leveraged the results of our work on a neurally motivated model of reflexive reasoning to design a real-time large-scale knowledge based reasoning system. We have completed the implementation of a system on the CM-5 and tested it with (i) large randomly generated knowledge bases and (ii) WordNet, a lexical database containing knowledge about hypernym, hyponym, synonym, and antonym relationships between lexical items. In the first case, the system responds to retrieval queries in under 10 msec. and inferential queries of upto depth 5 in under 200 msec. In the second case, the system exhibits a speed-up of 5-450 compared to a traditional serial implementation of WordNet. I remain interested in making the system available for applications, of potential interest to the military, that might benefit from the capabilities of this efficient large-scale knowledge-based system.

Attachment for: ONR SEMI-ANNUAL PRODUCTIVITY REPORT, 01 OCT 1994 31 MAR 1995

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Progress Summary

The results of our work on a biologically motivated model of reflexive reasoning were used to implement a large scale system for performing rapid reasoning using very large knowledge bases. The system — SHRUTI-CM-5 runs on a 32 node CM-5, and has been tested on a large randomly generated knowledge base containing over 500,000 items and WordNet, a real-world lexical database. The system's response time is fast enough to support retrieval and inferencing for real-time applications such as speech understanding. We have also made some progress in addressing the catastrophic interference problem.

Progress Report

We have continued our investigation of the representational capabilities of spatio-temporal networks and their application to reflexive reasoning. We have leveraged the results of our reflexive reasoning system based on temporal synchrony to build a system for performing rapid reasoning using very large knowledge bases. The system's response time is fast enough to support inferencing for real-time applications such as speech understanding. The system can respond to retrieval as well as inferential queries within a few hundred milliseconds. The system running on a 32 node CM-5 has been tested on (i) a randomly generated knowledge base of over 500,000 rules, facts, and types and (ii) WordNet, a lexical database containing knowledge about hypernym, hyponym, synonym, and antonym relationships between lexical items. In the first case, the system responds to retrieval queries in a few msec. and inferential queries of up to depth 5 in under 200 msec. In the second case, the system exhibits a speed-up of 5-450 compared to the serial implementation. This work will lead to the PhD dissertation of D.R. Mani (expected date of completion, August 1995).

As reported previously, we are investigating a possible solution to the "catastrophic interference problem". This problem is perhaps the biggest impediment in the development of scalable learning systems. The solution under investigation is as follows: Initially the system focuses on a small number of categories. After it learns these categories, it tries to identify which features formed in the "hidden layer" play a crucial role in the recognition of these categories. The system "freezes" these crucial features by fixing their input weights and as a result, they cannot be obliterated by subsequent learning (although the features may undergo some fine tuning). These frozen features however, are available for solving other tasks and can be a part of structures learned subsequently to recognize other categories. Our hope is that the set of features will gradually stabilize and eventually, learning a new category will primarily consist of combining existing features in novel ways. These ideas are being investigated in the context of training spatio-temporal networks to recognize digit strings. Our efforts thus far have been moderately successful. A strength of learning algorithms such as backpropagation is that they produce "distributed" and highly redundant representations. This attribute however, becomes a drawback in the context of our approach because it makes it difficult to isolate a compact set of critical features. Our current effort is focused on (i) identifying a suitable objective function that would prompt the hidden layer to learn relatively compact representations and ii) developing a robust but tractable criteria for identifying a set of critical features (the problem of identifying an optimal set of critical features is intractable since doing so requires the evaluation of all 2^n possible subsets of n hidden nodes). We are

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LOKENDRA SHASTRI

Refereed Journal Paper accepted

1. "Recognizing hand-printed digit strings using a modular spatio-temporal connectionist network", L. Shastri and T. Fontaine. To appear in *Connection Science.*

Book Chapter Published

1. "Reasoning with rules and variables in neural nets", V. Ajjanagadde and L. Shastri. In *Intelligent Hybrid Systems,* S. Goonatilake and S. Kebbal (Eds). John Wiley & Sons. 1995.

Book Chapter in Press

1. "Structured Connectionist Model", L. Shastri. In *The Handbook of Brain Theory and Neural Networks,* M. Arbib (Ed), MIT Press. In Press.

Invited Colloquia

1. Joint Philosophy, Neuroscience and Psychology Colloquium, Washington University St. Louis. Oct. 1994.

2. AI and Robotics Seminar, Division of Computer Science, University of California at Berkeley. March. 1995.

Contributed Presentation

1. "A spatio-temporal approach to visual pattern recognition" in the workshop on "Neural Network Architectures with Time Delay Connections for Nonlinear Signal Processing: Theory and Applications". NIPS*94, Vail Colorado. Dec. 1994.

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